CLAIMS

What is claimed is:

1. A pen stroke simulation device installed in a main system, the main system connecting to a handwriting pen by a signal transmission line, the handwriting pen comprising:

a pen tip;

a pen tip position sensor for capturing a main position coordinates of the pen tip on a handwriting tablet that generates a main position data;

a pressure sensor for sensing pressure by the pen tip on the handwriting tablet and generating a pressure value;

wherein the handwriting pen transfers the main position data and the pressure value through the signal transmission line to the main system;

the pen stroke simulation device comprising:

a pressure-radius transformation module for receiving the pressure value and transforming the pressure value to a radius value;

a positive vector generation module for receiving the main position data and generating a positive vector data according to the main position data;

a density location generation module connecting to the pressure-radius transformation module and the positive vector generation module for generating a plurality of density location data in the direction of the positive vector at the main positions based on the

radius and the positive vector data to express a plurality of coordinates of the density locations; and a pen stroke generation module for drawing a main line according to the pen tip sliding across the main positions over time and drawing a plurality of density lines according to the density location data where each main position data corresponding to a plurality of the density location data.

2. A pen stroke simulation device as claimed in claim 1, wherein the pressure-radius transformation module employs a pressure-radius transformation equation to transform the pressure value Z into a radius value ϖ, the pressure-radius transformation equation being represented as:

$$\begin{cases} \varpi = f(z) = (Max\varpi) * \left(\dfrac{e^{z} - 1}{e - 1} \right) \\ where \\ f(0) = 0 \\ f(1) = Max\varpi \\ 0 \le Z \le 1 \end{cases} ;$$

where $Max\varpi$ being the maximum preset value of radius.

3. A pen stroke simulation device as claimed in claim 2, wherein the positive vector generation module first acquires an instantaneous direction of the pen tip on the main position coordinate according to the main position data, the equation being expressed as:

$$V_i = \frac{O_i - O_{i-1}}{\left|O_i - O_{i-1}\right|};$$

where V_i representing the instantaneous direction of the pen tip over time t_i, O_i representing the main position coordinates of the pen tip over time t_i, and O_{i-1} representing the main position coordinates of the pen tip over time t_{i-1};

if $V_i = (x, y)$, the positive vector data $N_i = (-y, x)$.

4. A pen stroke simulation device as claimed in claim 3, wherein the density location generation module employs a density location generation equation to generate a plurality of density location data, the equation being represented as:

$$b_{i,j} = O_i + \varpi\left(\frac{j}{n} - 1\right) \cdot N_i$$

where O_i representing the main position coordinates of the pen tip over the time t_i, ϖ representing the radius data, N_i representing the positive vector data, and n representing a system preset value used for forming number of the density location data, and b_{ij} representing the j^{th} density location coordinates of the i^{th} main position coordinates;

where the stroke drawn by the handwriting pen, comprising m main position data, and each main position data corresponding to n density location data.

5. A pen stroke simulation device as claimed in claim 4, wherein the stroke generation module employs the stroke forming method to form the main line and a

plurality of density lines, assuming the main line is formed by m main position coordinates and each main position coordinates corresponds to n density location coordinates, the method including:

computing tangent vectors T_i and T_{i+1} of the i^{th} and $(i+1)^{th}$ position coordinates, the equation being:

$$\begin{cases} T_{i+1} = a * (P_{i+1} - P_i) \\ a \in [0,1] \end{cases} ;$$

where P_{i+1} being the $(i+1)^{th}$ position coordinates, and P_i being the i^{th} position coordinates;

employing Blending functions to estimate the interpolating value between the i^{th} and $(i+1)^{th}$ position coordinates, the Blending functions being shown as follows:

$$\begin{cases} h_1(s) = 2s^3 - 3s^2 + 1 \\ h_2(s) = -2s^3 + 3s^2 \\ h_3(s) = s^3 - 2s^2 + s \\ h_4(s) = s^3 - s^2 \\ 0 \le s \le 1 \end{cases} ;$$

acquiring a Cardinal Splines Curve, and the equation being:

$\vec{P} = \vec{P}_i * h_1 + \vec{P}_{i+1} * h_2 + \vec{T}_i * h_3 + \vec{T}_{i+1} * h_4$; and

computing the medium coordinate position between the i^{th} and $(i+1)^{th}$ position coordinates, and linking the entire coordinate positions to form a smooth curve, the equation of the medium coordinate position being:

$P = S * h * C$;

where

$$S=\begin{bmatrix} s^3 \\ s^2 \\ s^1 \\ 1 \end{bmatrix} \qquad C=\begin{bmatrix} P_i \\ P_{i+1} \\ T_i \\ T_{i+1} \end{bmatrix} \qquad h=\begin{bmatrix} 2 & -2 & 1 & 1 \\ -3 & 3 & -2 & -1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}.$$

6. A pen stroke simulation device as claimed in claim 1, wherein the stroke generation module comprising:

a color parameters generation module, used to generate color parameters, relative to the main position data and the density location data through a random number generator.

7. A pen stroke simulation device as claimed in claim 6, wherein the color parameters generation module employs a color parameters generation equation to form the color parameters ρ_i, the equation being as follows:

$$\begin{cases} \rho_i = \rho_1 + \|rand()\| \% (\rho_2 - \rho_1 + 1) \\ where \\ \rho_1 \le \rho_i \le \rho_2 \\ \rho_1 ,\ \rho_2 \in [0,255] \end{cases} ;$$

where ρ_1 and ρ_2 being system preset values.

8. A pen stroke simulation device as claimed in claim 7, wherein the stroke generation module comprising:

a speed parameters generation module for generating speed parameters relative to the main position data and the density location data; and

a speed-color parameters generation module for generating a speed-color parameters according to the

color parameter and speed parameter.

9. A pen stroke simulation device as claimed in claim 8, wherein the speed parameters generation module employs a speed parameters generation equation to generate the speed parameter V, the equation being as follows:

$$V = f(\nu) = \left(\frac{\nu_{\max}^3 - 3\nu_{\max}\nu^2 + 2\nu^3}{\nu_{\max}^3} \right);$$

where ν representing the instantaneous speed of the handwriting pen at the main position coordinates, and ν_{max} representing a preset maximum speed; and

the speed-color parameters generation module employing a speed-color parameters generation equation to generate the speed-color parameter ρ_i', the equation being as follows:

$$\rho_i' = \rho_i * V.$$

10. A pen stroke simulation device as claimed in claim 1, wherein the stroke generation module comprising:

a shade parameters generation module for generating the shade parameters relative to the main position data and the density location data according to the pressure value.

11. A pen stroke simulation device as claimed in claim 10, wherein the main position data possesses the maximum value of the shade parameters, and the farther the distance from the main position coordinates, the

smaller the shade parameter value of the density location data is.

12. A pen stroke simulation device as claimed in claim 11, wherein the shade parameters generation module employs a shade parameters generation equation to form shade parameter λ, the equation being as follows:

$$\lambda = (1-\lambda_0)(1-e^{-az}) + \lambda_0 \quad ;$$

where a being a user defined constant, z being the pressure value, and λ_0 being a preset value of the shade parameters;

where the value of the pressure in the above equation exceeding a certain predefined value, the shade parameter approaching a constant.

13. A pen stroke simulation device as claimed in claim 1, wherein the stroke generation module comprising:

a dispersion parameters generation module generating a plurality of dispersion position data according to the main position data and the radius data ω for representing a plurality of dispersion positional coordinates where each main position data corresponding to a plurality of dispersion position data.

14. A pen stroke simulation device as claimed in claim 13, wherein the dispersion parameters generation module consists of a dispersion parameters D, which is used to decide the distance between every two of the

dispersion position coordinate q, and employs a dispersion position generation equation to generate dispersion positional coordinates, such that the farther the distance from the main position coordinates, the shorter the distance between the dispersion positional coordinates is, the equation being as follows:

$$\frac{\partial q}{\partial t} = D\nabla^2 q \quad ;$$

where the equation being expanded by employing the finite difference method:

$$\Rightarrow \frac{q_{i+1} - q_{i-1}}{2t} = D \cdot (q_{i+1} - 2q_i + q_{i-1})$$
$$\Rightarrow q_{i+1} = q_{i-1} + 2Dt \cdot q_{i+1} - 4Dtq_i + 2Dtq_{i-1}$$
$$\Rightarrow q_{i+1} = \left(\frac{1}{1-2Dt}\right)(-4Dtq_i + (1+2Dt)q_{i-1}) .$$

15. A pen stroke simulation device as claimed in claim 13, wherein each dispersion position data corresponds to a dispersion color data, and the dispersion parameters generation module consists of a dispersion parameters D, to determine the variation in color between every two of the dispersion color data q, and to employ a dispersion color generation equation generating the dispersion color data, such that the farther the dispersion position from the main position, the smaller the difference between the dispersion color data is, the equation being as follows:

$$\frac{\partial q}{\partial t} = D\nabla^2 q \quad ;$$

where the equation being expanded by employing the

finite difference method:

$$\Rightarrow \frac{q_{i+1} - q_{i-1}}{2t} = D \cdot (q_{i+1} - 2q_i + q_{i-1})$$
$$\Rightarrow q_{i+1} = q_{i-1} + 2Dt \cdot q_{i+1} - 4Dtq_i + 2Dtq_{i-1}$$
$$\Rightarrow q_{i+1} = \left(\frac{1}{1-2Dt}\right)(-4Dtq_i + (1+2Dt)q_{i-1})$$

16. A pen stroke simulation device as claimed in claim 1, wherein the stroke generation module comprising:

a pause parameters generation module generating the pause parameters corresponding to the main position data and the density location data for determining whether the main position data and the density data will be seen.

17. A pen stroke simulation device as claimed in claim 16, wherein the pause parameters generation module consists of a table of preset values for the pause parameters, possessing a plurality of the pause parameters, for corresponding to the main position data and the density location data;

where the pause parameter being set to a first value, the corresponding position data being shown up, otherwise, a setting of a second value disabling the appearance of the corresponding position data;
the pause parameters d being represented as:
$d = dTable(i)$; where d ∈ [0, 1].

18. A pen stroke simulation device as claimed in claim 1, wherein the stroke generation module

comprising:

a color parameters generation module for generating color parameters, relative to the main position data and the density location data through a random number generator, where the color parameters generation module employing a color parameters generation equation to form the color parameters ρ_i, the equation being as follows:

$$\begin{cases} \rho_i = \rho_1 + \|rand()\|\%(\rho_2 - \rho_1 + 1) \\ where \\ \rho_1 \le \rho_i \le \rho_2 \\ \rho_1 , \ \rho_2 \in [0,255] \end{cases},$$

where ρ_1 and ρ_2 being system preset values;

a speed parameters generation module, for generating speed parameters, relative to the main position data and the density location data, where the speed parameters generation module employing a speed parameters generation equation to generate the speed parameter V, the equation being as follows:

$$V = f(v) = \left(\frac{v_{\max}^3 - 3v_{\max} v^2 + 2v^3}{v_{\max}^3} \right),$$

where ν representing the instantaneous speed of the handwriting pen at the main position coordinates, and ν_{max} representing a preset maximum speed;

a shade parameters generation module, for generating the shade parameters, relative to the main position data and the density location data, according to the pressure value, where the main position data possessing the maximum value of the shade parameters, and the farther the distance from the main position

coordinates, the smaller the shade parameter value of the density location data being, the shade parameters generation module employing a shade parameters generation equation to form shade parameter λ, the equation being as follows:

$$\lambda = (1-\lambda_0)(1-e^{-az})+\lambda_0 ,$$

where a being a user defined constant, z being the pressure value, and λ_0 being a preset value of the shade parameters, once the value of the pressure in the above equation exceeding a certain predefined value, the shade parameter approaching a constant;

a pause parameters generation module, for generating the pause parameters corresponding to the main position data and the density location data, to determine whether the main position data and the density data being seen, where the pause parameters generation module consisting of a table of preset values for the pause parameters, possessing a plurality of the pause parameters, which corresponding to the main position data and the density location data, once a pause parameter being set to a first value, the corresponding position data being shown up, otherwise, a setting of a second value disabling the appearance, the pause parameters d being represented as:

$d = dTable(i)$, where $d \in [0, 1]$; and

a stroke-color parameters generation module, used to generate the stroke-color parameters, according to color parameters ρ_i, rate parameters V, shade parameters λ, and pause parameters d, and the stroke-color parameters generation module employing a stroke-color

parameters generation equation to compute the stroke-color parameters $C_{i,j}$, the equation being represented by:

$$C_{i,j} = \lambda * C_{i,j-1} * d * V;$$

where the stroke drawn by the handwriting pen, comprising m main position data, and each main position data corresponding to n density location data, and $C_{i,j}$ representing the stroke-color parameters to which the j^{th} density location coordinates of the i^{th} main position coordinates corresponding.

19. A handwriting pen, through a signal transmission line connecting to a main system, said handwriting pen comprising:

a pen stick;

a pen head fixed at one end of the pen stick and being made of soft material;

a gear fixed inside the pen head, wherein the pen head deforming, the gear undergoing a proportion of rotation accordingly;

a rotational velocity detector fixed inside the pen head for detecting rotation of the gear, and calculating a rotational velocity and a rotational direction according to the diameter and the length of cog of the gear; and

a pressure generator connected to the rotational velocity detector for receiving the rotational velocity data and the rotational direction data of the gear through which a pressure value being generated;

where the pressure being sent to the main system

through the signal transmission line.

20. A handwriting pen as claimed in claim 19, further comprising a central stick, comprising:

a first stick extending from the pen stick into the pen head;

a second stick located in the pen head; and

a spring for joining the first stick to the second stick;

wherein the gear is fixed at the lateral of the central stick, locating in between the first stick and the second stick, and the rotational velocity detector is fixed at the lateral of the first stick, and located on the top of the gear; once the pen head deforms, the spring would bend under that force, and causes the gear rotating a proportion.

21. A handwriting pen as claimed in claim 20, further comprising:

a pen tip fixed at one end of the second stick and extending beyond the pen head; and

a pen tip position sensor fixed in the pen tip for sensing the position coordinate of the pen tip on the handwriting tablet;

where the position coordinates associated with the pressure value being sent to the main system through the signal transmission line.

22. A handwriting pen as claimed in claim 19, wherein the pressure generator comprising:

a signal processor for receiving the rotational velocity data and the rotational direction data of the gear through which a tangent velocity of rotation of the gear being generated; and

a pressure signal transformer connected to the signal processor for receiving the tangent velocity of rotation and generating the pressure value according to the tangent velocity of rotation.

23. A handwriting pen as claimed in claim 22, wherein the signal processor comprising:

a gear position sensor for sensing rotational position of the gear and signaling a position once sensing a cog of the gear;

a direction sensor for sensing rotational direction of the gear and signaling a direction; and

a rotational tangent velocity generator connected to the position sensor and the direction sensor for receiving the position signal and the direction signal, where the rotational tangent velocity generator employing a quotient, dividing perimeter of the gear by the number of cogs, for computing distance between every two cogs, and employing another quotient, dividing the distance between cogs by time interval of every two position signals, for computing the tangent speed of rotation of the gear, and applying the direction signal, to determine the direction of the tangent speed of rotation, and integrating the speed and direction values to obtain the resulting tangent velocity of rotation;

where the rotational direction of the gear being clockwise, the direction signal being 1, otherwise, -1 for a counterclockwise rotational direction, therefore, the equation of calculating the tangent velocity of rotation being as follows:

$V_t = \pm 1 \times P/N_c \times 1/T_i$,

where

V_t: tangent velocity of rotation

P: perimeter of the gear

N_c: number of cogs

T_i: time interval.

24. A handwriting pen as claimed in claim 22, wherein the pressure-signal transformer comprising:

an angle calculator for receiving the tangent velocity of rotation for computing bending angle θ_2 of the pen head according to the tangent velocity of rotation; and

a angle-pressure transformer connecting to the angle calculator for receiving the bending angle θ_2, and to generate the pressure value according to the bending angle θ_2;

where the angle calculator comprising the known parameters:

r: the length of the pen head;

θ_1: the bending angle of the pen head over time t;

∂_1: the angular acceleration of the gear rotates over time t;

ϖ_1: the angular velocity of the gear rotates over time t; and

Δt: a unit time;

where the tangent velocity of rotation, received by the angle calculator being represented by v_2, which being the tangent velocity of the gear rotates over time $t+\Delta t$;

hence, the equation of the rotational angular velocity ϖ_2 of the gear over time $t+\Delta t$:

$$\varpi_2 = \frac{v_2}{r} \quad ;$$

hence, the equation of the rotational angular acceleration ∂_2 of the gear over time $t+\Delta t$:

$$\partial_2 = \frac{(\varpi_2 - \varpi_1)}{\Delta t} \quad ;$$

hence, the bending angle θ_2:

$$\theta_2 = \theta_1 + \varpi_1 * \Delta t + \frac{1}{2} * \partial_2 * \Delta t^2 \quad ;$$

wherein the angle-pressure transformer further comprises a preset angle-pressure variation table for generating a pressure calculation formula, and the angle-pressure transformer substituting the bending angle θ_2 of the pen head over time $t+\Delta t$ into the formula to compute the pressure value Z, the formula being as follows:

$$Z = \begin{cases} K_1 * \theta & , \text{if } 0 \le \theta \le \theta_a \\ K_2 * (\theta - \theta_a) + K_1 * \theta_a & , \text{if } \theta_a \le \theta \le \theta_b \\ K_3 * (\theta - \theta_b) + K_2 * (\theta_b - \theta_a) + K_1 * \theta_a & , \text{if } \theta \ge \theta_b \end{cases} \quad ;$$

where K_1, K_2, and K_3 being preset slopes, and θ_a and θ_b being preset angles.